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STRATEGIC WASTE MANAGEMENT PLANNING – THE ORGANIZATION OF MUNICIPAL SOLID WASTE COLLECTION IN OULU, FINLAND*

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Abstract: Municipal solid waste management is a basic service that, in Finland, consists of collection, transportation and treatment systems provided by municipalities, waste management companies and producer responsibility organizations. The amount of municipal solid waste in Finland has risen quite steadily for many decades. In 2012, the recovery rate of municipal solid waste as material or energy was 67%. The Finnish Waste Act has been updated in 2012, with the key goal to further reduce waste amounts and progress recycling. The paper describes the best practices in strategic waste management planning and describes the organization of municipal solid waste in city of Oulu, Finland.

Keywords: Municipal solid waste, Recovery, Extended producer responsibility

1. Introduction

Municipal Solid Waste (MSW) usually implies all the waste fractions, which are handled in the municipal waste management system e.g. kitchen waste, packaging materials, glassware and tin cans. MSW is generated in households, trade, industries, construction and public and private institutes. Some part of MSW is composted, recycled or otherwise recovered as material, whereas some of the waste is incinerated or gasified, and the rest is land-filled [1]. Waste management means the collection,

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transportation, utilization and treatment of waste and it includes the controlling of these activities and aftercare of the treatment places [2]. The Municipal Solid Waste Management (MSWM) system generates recovered materials to be reprocessed for markets, recovered nutrients in the form of compost for markets, and waste to be land-filled [3].

Directive 2008/98/EC (the Waste Framework Directive, WFD) presents the basic concepts and definitions related to waste management. The WFD defines the concept of waste, recycling and recovery; it also describes when waste ceases to be waste (end-of-waste criteria) and specifies the difference between wastes and by-products. The WFD presents waste management principles and it requires waste to be managed without endangering human health and the environment. EU Member States shall also obey the waste management hierarchy, with waste prevention the first priority, followed by preparing for re-use, recycling, other recovery and, finally, disposal [2]. The waste legislation and waste policy in Finland is based on the waste hierarchy set by the WFD. The Finnish Waste Act has been updated in 2012 to further reduce waste amounts and to progress recycling [4].

Some products fall under Extended Producer Responsibility (EPR). EPR entails the responsibility of the producer over the recovery of product at the end of its useful life. Producers are obliged to finance and organize the collection, pre-processing, recycling, utilization and waste management of their products removed from use. They can take care of this responsibility themselves or transfer the recovery obligation to producer organizations [5]. In EPR, the producers are the manufacturers and importers of the products or, in the case of packaging, packagers and the importers of packaged products. EPR covers Waste Electronic and Electrical Equipment (WEEE); batteries and accumulators; cars and vans; tires from motor vehicles and other vehicles; newspapers, magazines, copy paper, and other comparable paper products and packaging [6].

Sustainable MSWM is challenging in the EU, due to increasing per capita waste generation, the need for expensive investments in the physical infrastructure i.e. construction of incinerators, landfill and recycling facilities, institutional barriers, a large amount of stakeholders and overlapping policies. In addition, the composition and amounts of wastes vary over time and space and the market for recoverable is uncertain and prices are fluctuating [7]. The challenges lay heavier on the new; Southern European Member States that need to develop proper integrated MSWM systems and reach the targets of EU Directives. At the same time, older EU countries need to rationalize their technological choices and MSWM strategies [8]. For example, in a model of the strategic planning of integrated MSWM system for the Helsinki region, the potential separation strategies, material amounts, costs and emissions were possible to be estimated [9]. However, the major challenge of using MSWM models is the difficulty to generalize them and adapt to other situations [10].

The objective of this article is to present the basic elements of strategic municipal waste management planning. Further, the current MSWM system in Finland is presented, and the challenges of sustainable MSWM in sparsely populated countries are illustrated with the example of the city of Oulu in Northern Finland.

2. Strategic municipal waste management planning

MSW is a significant challenge for all societies. Solving waste problems needs many technical, legislative and economic measures [11]. EU legislation requires from Member States to prepare waste management plans, following relevant EU directives [12]. According to [2], Equ. (1) of the WFD, Member States need to make sure that there is an adequate network of waste disposal facilities that use best available technologies not entailing excess costs [13]. As MSWM is an important activity and an essential employer, it may cover 10-50% of a municipal operational budget. Moreover, it is an essential municipal service that is paid by the customers using the service through taxes and charges [14]. To achieve a rational and well-functioning MSWM system, the principles of sustainable development, integrated solid waste management, and the waste management hierarchy must be included and practiced at all levels, from national to municipal and institutional. The governments on each level are responsible for ensuring that planned activities occur within their own jurisdiction and indicators are used to observe accomplishment [15].

MSWM planning differs substantially on national and local or regional levels [12]. The role of national government in integrated MSW management is three-fold: it needs to develop and enact legislation and policies, which assist and confirm the protection of the environment; it must establish an agency or department to execute these programs, and to perform essential research and development. The implementation phase of the MSW programs and other activities is usually delegated to lower levels. The role of government in lower levels in integrated MSW management should also be three-fold so that the last level would be the regulation of solid waste management practices. These levels should directly be part of the planning process for MSWM and they should also improve the research and development and pilot projects in the field. The municipal government is responsible for the implementation of municipal MSW programs and facilities within their jurisdiction and it makes a decision if the municipality is directly involved in providing MSW services or if they are licensing companies to provide these services. All the adopted activities on all levels should be in line with legislation, policies and programs [15].

Waste management plans have an important role in achieving sustainable waste management and their main goal is to give an outline of waste streams and waste treatment options [12]. Strategic planning is essential to MSWM services to meet the demand, to be suitable to needs, and to be cost-effective. Planning is a continuing process and the service must be evaluated and revised constantly to ensure sustainable improvements to future service coverage and standards. [12], [14] The planning process consists of six phases (*Fig 1*):

- general considerations;
- status part;
- planning part;
- consultation process;
- implementation and
- plan revision [12].

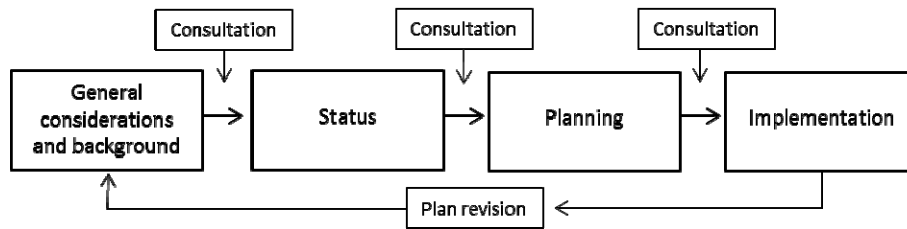


Fig. 1. The MSWM planning process [12]

The background and general considerations part includes the EU waste management principles and EU directives that need to be followed. In the status phase, all data and information on the existing situation are collected and evaluated. A central element of the planning part is determination of political objectives by selecting priority waste streams or waste treatment methods and by developing indicators to monitor if the objectives are met most effectively. In the consultation process, the public should be involved in the selection of the waste management system. Finally, in the implementation phase, orientations of the plan are put into practice by legislation, regulation, negotiations with the industry, and/or information to the public. A plan revision is needed before the end of the planning period [12].

Strategic MSWM planning can further be divided into two categories: Strategy and Action Plan (Table I).

Table I

Scope of a strategic MSWM plan [14]

Strategy	Action Plan
Overall vision	Pre-feasibility studies for technical options covering:
Goals and objectives (national/areal/municipal)	<ul style="list-style-type: none"> •collection and recycling •treatment and disposal
National policy framework	Plans covering:
Development planning framework	<ul style="list-style-type: none"> •institutional/organizational development •service/facilities development •financial management and cost recovery •public awareness and participation
Roles and responsibilities	Investment plan
Waste streams to be covered	Timetable for detailed feasibility study and implementation
Waste collection targets	Immediate action plan
Promotion of waste recycling	
Waste treatment and disposal policy	
Public awareness requirements	
Policy on private sector participation	
Cost recovery and financial management policy	
Outline investment requirements	
Timetable for action planning	

The Strategy part presents the overall framework for MSWM systems and standards, whereas the Action plan part consists of the specific options to be achieved, in order to meet the requirements set out in the strategy part. Detailed design work (called Operational planning) is needed to set the precise arrangements for the implementation of the strategic planning. The goal of strategic planning is also to generate a practical plan, with a foreseeable impact on MSWM services when implemented [14].

3. Municipal solid waste management in Finland

Municipal solid waste management (MSWM) in Finland is a basic service with considerations of citizens' health and the state of the environment. MSWM in Finland is a part of the infrastructure of the municipalities and it is organized by the municipalities, companies and producer responsibility organizations. Municipal waste companies are cooperating with industry and producer organizations in organizing MSWM services countrywide [16].

The amounts of MSW rose quite steadily for many decades until 2008 but, in 2009 and in 2010, the amounts of produced and land-filled MSW decreased slightly [17], rising again to 2.74 million tons in 2012 (*Fig. 2.*) [18].

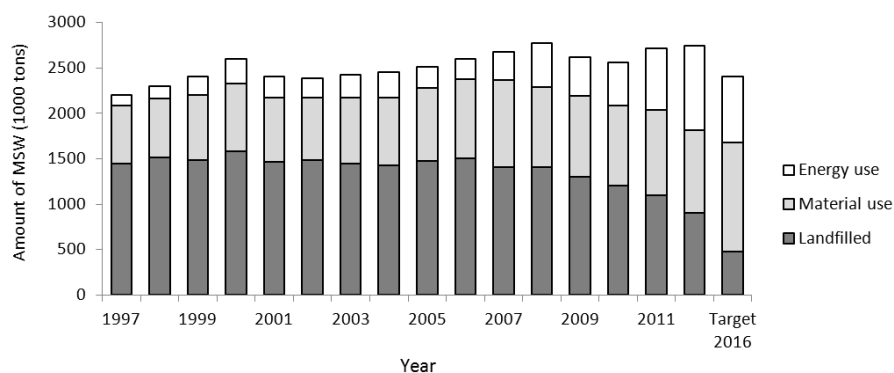


Fig. 2. Amounts of MSW in Finland during 1997-2012 [18] and target for year 2016 [30]

The amount of MSW per inhabitant was 506 kg in 2012 [19]. The amount of generated waste usually increases as the living standards become higher [20]. The decrease in waste amounts between 2008 and 2010 can be explained by the impact of the economic recession. In 2009, the consumption expenditure of households declined 1.8% and net sales of the service sector dropped 7.5% [17]. The positive element in this de-growth is that the decline is especially seen in wastes going for landfill. The authors would like to believe that this indicates people parting with their habits of excess buying, although the amount of MSW produced rose again after 2010.

About 60 % of MSW is generated by households and the rest is produced in the service sector [21]. It is estimated that about half of MSW is biodegradable; foodstuff, wastepaper and fiberboard (*Fig. 3*) [17].

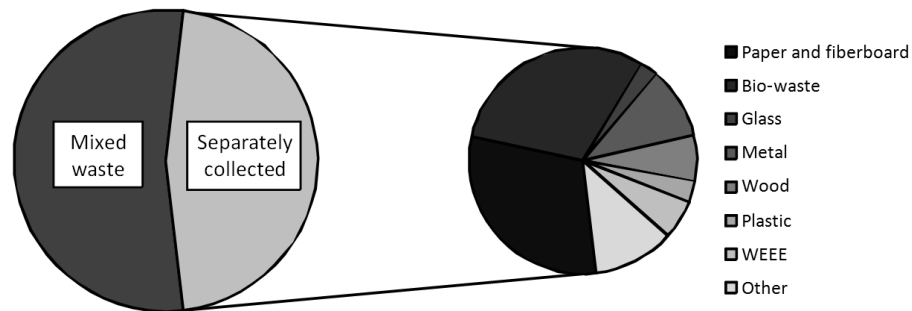


Fig. 3. Fractions of MSW in Finland in 2012 [18]

Waste recovery rates vary strongly depending on the waste sector. The recovering rates of MSW have increased in Finland because of improved sorting and separate collection [21]. In 2012, the total recovery rate of MSW as material and energy was 67%, but it was not due to improved recycling since the material use of MSW decreased whereas the energy use of MSW increased. The energy use of waste material is 33% of the MSW produced annually (Fig. 2) [18]. The highest recovery percentages have been achieved for paper and fiberboard, bio-waste, glass and metal [22].

3.1. Economic instruments

The intention of economic instruments is to create incentives for people to change their behavior, for instance by finding ways to prevent wastage or motivate for more environmentally friendly waste management options, thus reducing environmental pressure. Common economic incentives are waste charges for collection and transportation of waste, and waste taxes, charges and fees such as taxes on landfill and packaging [12]. Table II lists the economic instruments and their amounts in Finland. Waste charge rates are set by municipalities and the waste holders need to pay them. Commonly, the charges are lower for sorted wastes and for wastes that can be recovered. The waste tax is levied on waste deposited at landfill if its utilization is technically feasible and environmentally justifiable and, if by levying the tax, waste can be made more commercially exploitable. Waste taxes are for wastes that are transported to public landfill sites but, if wastes are acceptably treated, e.g. through composting or incineration, there is no need to pay waste taxes. Drinks packaging taxes are for packages for alcoholic beverages, soft drinks, bottled water and certain other drinks packages [23].

3.2. MSWM in the Oulu region

According to the waste management regulations of the City of Oulu, all properties are obliged to have collection containers for combustible wastes. In addition, residential buildings with a minimum of four apartments must have separate collection containers for waste paper, carton and liquid packages, metal, glass and bio-waste.

Table II

Economic instruments in Finland [23]

Economic instrument	Purpose	Amount of the charge
Municipal waste charge	Waste transportation Establishment, maintenance, decommissioning and after-care of treatment facilities	Waste tariff for mixed MSW approved by the municipality
Waste tax	Maintenance and waste guidance To encourage the public to reduce waste To make waste less harmful To utilize waste	Smaller fee for waste that is sorted and fit for recovery 50 euros/ton
Drinks packaging taxes	To encourage the reuse of drinks packages To reduce the land-filling of drinks packages	0.51 euros/liter
Oil waste charges	To prevent litter Managing oil wastes Cleaning up soil and groundwater contaminated with oil	5.75 euro cents/kilo

Other properties, for instance office and business premises, industrial properties, schools and restaurants need to have collection bins for waste paper, for bio-waste if the property has a canteen or a food-store, or if bio-waste is produced 20 kg/week (on average), as well as for cardboard, metal, carton, glass and waste wood if produced over 10 kg/week/fraction. Bio-waste need to be transported to a licensed composting plant or composting area by using organized waste transportation, or they need to be composted on-site. All the separately collected waste fractions need to be recycled. Small residential buildings are responsible to transport their recyclables to the regional waste collection points and to compost their bio-waste if possible. Some recyclables need to be collected separately in public events [24]. Fig. 4 presents the MSWM system of the city of Oulu.

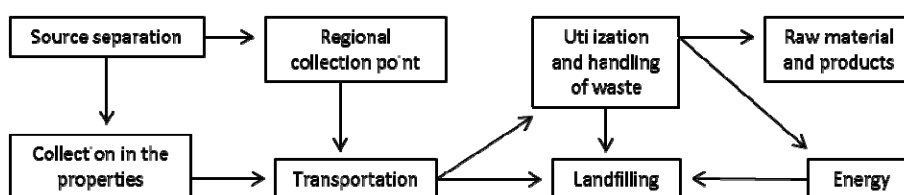


Fig. 4. MSWM system in Oulu region

The Oulu Waste Management Company (Oulun Jätehuolto) is a public-service company of the city of Oulu, which is responsible for waste treatment, coordination of waste transportation and waste education and supplementary services. The operation

area of Oulu Waste Management Company consists of 12 municipalities and almost 290 000 residents. Tax money is not used for the operations; the waste management operations are funded by the fees collected from the delivery of waste to the Rusko Waste Management Center and funds received from the sale of methane gas produced at the Waste Management Center, and from other services [25].

The Rusko Waste Management Center area is 93 hectares of which 5.5 hectares are in use for land-filling of mixed waste and construction waste. The remaining area is for other operations, for instance preparing for re-use stations, hazardous waste storage, composting area and offices. Hundreds of customers visit the waste center every day. Customers can bring their mixed waste for a charge to be land-filled, and re-usable and recyclable domestic waste and hazardous waste for free to the reception station at Rusko Waste Management Center called Oivapiste. Wastes with charge are weighed and paid according to weight and inherent hazard. Oivapiste accepts cardboard, paper, paperboard, metal, clean and untreated timber, small amounts of pressure treated timber, packing glass, tires, WEEE and hazardous waste for free [25].

Separately collected bio-waste from Oulu and other municipalities is handled in the composting plant. About 8000 tons of bio-wastes are treated in the Rusko Waste Management Center annually by using three specially designed composting drums [26]. The Rusko Center also recovers the gas from the landfill. One third of the landfill gas is used to produce electricity and the rest two thirds to produce heat. Electricity and heat are used in the Rusko Waste Management Center area and the remaining excess electricity is sold to the national power grid. The recovered methane is also utilized by the Paroc factory and by the Oulu University Hospital [25]. Starting from the year 2015, bio-waste will be treated in a new anaerobic digestion plant, which can also receive waste-water sludge and waste fat from the food industry and will provide services regionally. It can receive up to 19 000 tons of feedstock and will produce about 15 000 MWh of energy as biogas [26].

Apart from Oivapiste, there are also 73 smaller centralized reception stations for recyclables in Oulu Waste Management's operation area. These stations are located in areas that residents have adequate access to, for instance near large shopping centers or schools [25].

Due to this extensive network of waste reception stations and waste recovery infrastructure, the amounts of collected recoverable have increased steadily during the past ten years in Oulu. The composted bio-waste is used for landscaping and construction work at the waste center [26] and combustible waste fractions are incinerated in the Laanila incineration plant in Oulu [26], [27]. However, most of the recoverable are transported to recycling facilities outside Oulu, over relative large distances. *Fig. 5* illustrates the journey of recyclables from Oulu to recovery stations.

Waste metal is used as a raw material by the metallurgy industry [26], mostly in the Outokumpu factory in Tornio [27]. The collected waste paper and cardboard are used as a raw material in Kaipola [28]. While some of the collected glass is used in the earthworks of Rusko Waste Management Center [27], part of the glass is transported to Forssa to be used as raw material [28].

As the map in *Fig. 5* illustrates, the high waste recovery rates in Oulu come with a high price. It is due to the sparsely populated nature of Northern Finland, and economies of scale. The population density in North Finland is under 9/km², as

compared to the 17/km² of whole Finland. The area of North Finland (~160 000 km²) is about half of the landmass of Finland, but hosts only 26% (~1.5 M) of its population. The situation is even worse in Lapland, the northernmost area of Finland [29]. Waste recovery facilities are, understandably, located in the more densely populated southern areas. According to the National Waste Plan [30] of Finland, the primary aim is to stabilize the amounts of waste and, by the year 2016, 50% of MSW is to be recovered as material, and 30% as energy, with only 20% heading to landfill (Fig. 3). Considering present disposal rates and the pressure the 67% recovery percentage achieved is putting to some areas of Finland, this will be challenging.



Fig. 5. Transportation distances of recovered materials from Oulu to their utilization facilities

In addition, a general tendency in Finland is that a significant reduction in the number of landfills in progress. From the 1990s to recently, the number of landfills decreased in the Oulu region from 69 to 4, in Lapland from 94 to 3 and, in the Kainuu

region, from 24 to 1. This has resulted in the trend of more centralized waste treatment facilities with longer transportation distances. With the pressure to increase waste recovery percentages, it is not surprising that many waste operators in the North are increasingly interested in moving toward waste incineration. As only large-scale waste incineration plants are feasible, these developments will increase transportation distances even more. This seems to be the future of waste management of Finland; the need for a fewer, larger scale treatment facilities, and a network of transfer stations with considerable transportation distances in between.

4. Conclusions

EU legislation requires Member States to make waste management plans, which follow relevant EU directives. The increased level of waste recovery and decreased amount of disposed waste achieved in EU countries is due to requirements to follow the waste management hierarchy. If the amounts of wastes and MSW will continue to increase, considering the limited nature of virgin raw material sources, following the waste hierarchy will become even more essential in the future. Strategic MSWM planning is necessary for MSWM services to meet demand and needs cost-effectively.

Due to policy instruments, the infrastructure of waste management and the recovery of wastes have improved in Finland since the 1990s. The MSWM system in Finland operates at a good level, and meets the demand and the requirements of legislation. An essential element of waste recovery in Finland is the nationwide EPR collection network. Oulu has a well-established and well-functioning MSWM infrastructure with high reliance on curbside recovery of recyclables. Oulu is also a collection center for recyclables from a rather large, sparsely populated area. The efficiency of the collection system came with a rather high price, which, at the end, is paid by the consumers. It is this crucial element that explains the insistence on this level of recovery also in the North. As people in the North contribute to the same degree to environmental protection in forms of fees and taxes, they have the right to receive the same level of services as those in the South. It is yet to be seen how the waste management of Northern Finland will further evolve and if Finland will manage to further curb the amounts of wastes heading for landfill.

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